An Information System to Improve the Safety and Efficiency of Chemotherapy Ordering

Jonathan M. Teich, M.D., Ph.D., Jennifer L. Schmiz, B.A., Eileen M. O'Connell, R.N., John Fanikos, R.Ph, Peter W. Marks, M.D., Lawrence N. Shulman, M.D.,
Brigham and Women's Hospital, Partners Healthcare System, Boston, MA

We developed a computer application to support the ordering of chemotherapy. Key goals were to guard against errors in chemotherapy ordering and dosing, to coordinate the outpatient and inpatient chemotherapy services, and to support the overall process flow of a chemotherapy cycle. In a six-month period, 512 daily-dose and 386 weekly-dose warnings were generated; 167 (19%) resulted in a cancellation or re-evaluation of the dose. The system has been well accepted, and has helped to coordinate the efforts of the many members of the oncology care team.

INTRODUCTION

Correct dosing and safe administration of chemotherapeutic agents is imperative in the care of cancer patients. The complexity of care regimens and protocols inherently contribute to the risk of dosing errors. Additionally, the process of chemotherapy administration has become increasingly complex, which can lead to delays in treatment if care is not taken. A particular source of inefficiency is the first day of an admission for chemotherapy. If the process is not done efficiently, the patient may miss treatment on the first day, necessitating prolonged stay in the hospital.

Computer order entry[1,2] has been successful in promoting safe ordering by validating input, detecting possible errors and conflicts, and directing orderers to standardized protocols. In addition, the computer can potentially improve communication between the outpatient, pre-admission, and admission phases of treatment. Because of this potential, our information systems department was asked to participate in the development of a hospital-wide plan to improve the safety and efficiency of chemotherapy treatment.

PREVIOUS WORK

There has been a broad spectrum of efforts to use computer assistance in the treatment of cancer patients. Some systems use data-collection instruments to implement existing protocols and remind caregivers of required steps and next doses[3]. Other systems, such as ONCOCIN[4], have been developed to automatically calculate and recommend treatment based on a number of factors.

The Johns Hopkins Oncology Center has developed and maintained OCIS (The Oncology Information System) since 1975[5]. The primary intent of the system was to manage the large volumes of data inherent to oncology patients. The systems interface has been designed for physician access; physicians work directly with the system for assistance in decision making, while clinical data coordinators are used for entry and retrieval of data elements. The system has evolved to include graphic displays of trending data and protocol management. The pharmacy component of this system manages the automated medication administration record.

METHODS

Setting

Brigham and Women's Hospital is a 720-bed urban tertiary care center in Boston. The hematology-oncology service is one of the major specialties; chemotherapy is given to oncology patients in inpatient and outpatient settings.

Information systems at BWH is supplied by the Brigham Integrated Computing System (BICS)[6], an advanced clinical and administrative system with over 5000 workstations distributed over multiple sites. Order entry has been in place on all adult inpatient services since 1993. Before the current project, chemotherapy ordering was done agent by agent, in a fashion similar to regular medication ordering, although the entry screens provided and required different information, such as body-surface-area calculations and protocol names.

Chemotherapy safety committee

The BWH chemotherapy safety committee is a large multi-disciplinary group that consists of fellows and attending physicians, inpatient and outpatient nurses, pharmacists, nurse managers, and information systems staff. The committee is chaired by the medical director of the hematology-oncology division, and at times is facilitated by the vice

0195—4210/96/$5.00

president of clinical services. This group analyzed and developed the plan for the chemotherapy order entry module in both the inpatient and the outpatient setting.

The group met weekly for approximately four months until much of the chemotherapy ordering system was operational. The meetings have since become less frequent and are focusing on the integration of protocols and investigational drug data forms (IDDF's).

Goals

Safety. The committee's requirements called for several new features in order entry:

1) Routes of administration and units of measure (including complex denominators) should be clearly displayed.
2) The system should give warnings for doses that may exceed daily, weekly or lifetime limits.
3) A decision to bypass the warning should be documented and seen by all clinical team members.
4) The system should clearly differentiate chemotherapy agents, so that there is no chance of ordering them in inappropriate situations.
5) Both nursing and pharmacy should receive chemotherapy orders in a consistent manner. All necessary information pertaining to dose calculation should be contained in the order.
6) Reference to the Investigational Drug Data Form (IDDF) should be easily available.

Workflow. The goals for improved workflow included:

1) The treatment plan should begin in the outpatient oncology clinic, Ideally, chemotherapy should be started as soon as the patient arrives on the inpatient nursing unit.
2) Computerization of chemotherapy orders should be extended into the outpatient clinic and pre-admission center, to support this admission process.
3) Outpatient chemotherapy should be tracked in inpatient and outpatient settings, so that weekly and lifetime dose checking is more reliable.

SYSTEM OPERATION

Drug Dictionary

All chemotherapy agents used at BWH are selected from a drug dictionary. For each agent, the dictionary includes permissible routes of administration, dosing unit (e.g., mg/m^2 or U/kg), and rounding increment. The rounding increment converts the precisely calculated dose to an acceptably close form that is practical for the pharmacist to measure and deliver. Thus, a dose of 20 mg/m^2 multiplied by a BSA of 1.98 m^2 would calculate to 39.6 mg; the rounding increment for the agent may permit the dose to be rounded to 40 mg.

The chemotherapy agent dictionary also has fields

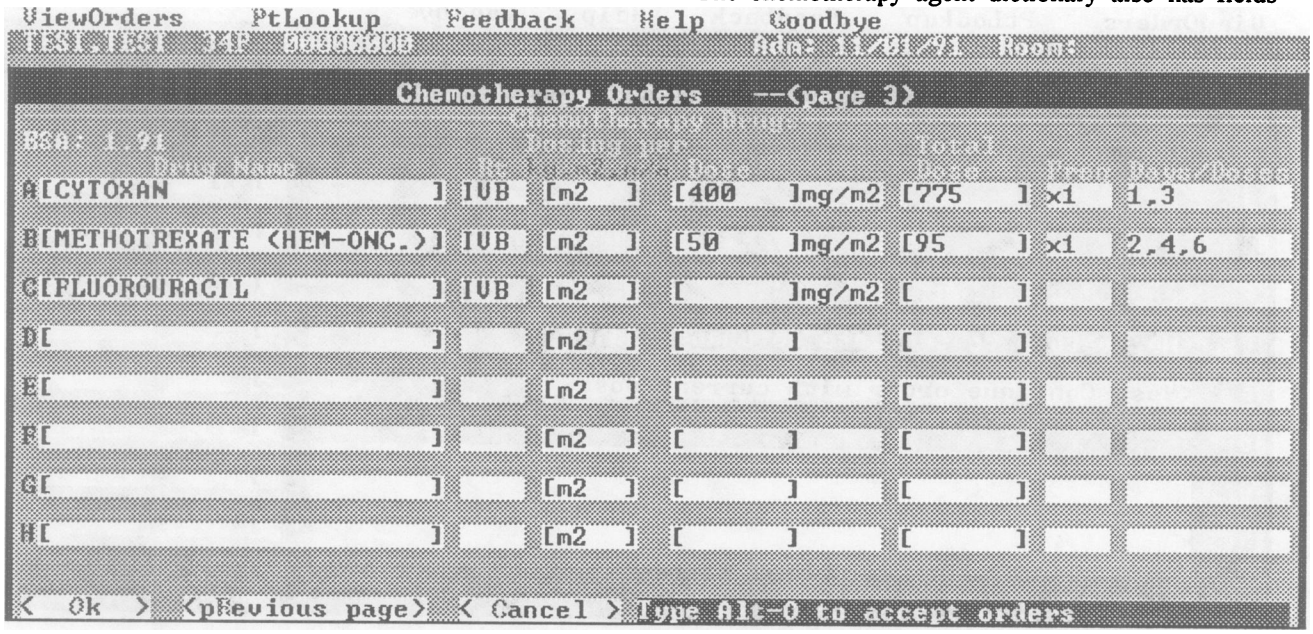

Figure 1 Screen for ordering chemotherapy. The computer assists the user with choice of units, proper dosing, and selecting the days of administration of each agent.

for maximum permissible daily, weekly, and lifetime dose for each agent. These can be expressed in multiple units; for example, vincristine has a maximum daily dose of 1.4 mg/m^2, but also an absolute maximum of 2.0 mg. Both of these numbers will be used in checking a given order.

Ordering

The chemotherapy template (Fig. 1), one of many order sets and templates used in order entry, is the interface to chemotherapy ordering. This template is a series of three screens. The first screen confirms the protocol, and other patient parameters such as height and weight for the body-surface-area calculation. The second screen contains tools for choosing related orders, including commonly ordered lab tests, pre-hydration and concurrent hydration, and anti-emetic medications. The third screen of the template is used to enter the chemotherapy agents.

The template makes it easy for the orderer to enter an entire cycle of a chemotherapy protocol. Each drug in the protocol can be entered on the same form; once the frequency of administration is chosen, the computer pops up a window from which the orderer can choose which days of the cycle to administer this agent. These days are specified in protocol fashion ("Day 1", etc.) and then are converted relative to the start of the cycle.

For agents ordered per kilogram or per meters squared, the system will calculate the total dose. The physician can override the calculated dose (beyond simple rounding off) but is required to specify the reason. This information is communicated to pharmacy and nursing when they receive the order. Some agents, such as carboplatin, use guided dose algorithms which base the dose on the patient's gender, age, and recent lab results. In this case, the system will access other BICS database areas to obtain the necessary data.

Dose checking

Once the dose is calculated, the system compares it to the specified limits. If the dose exceeds the daily maximum limit then the physician is presented with a warning screen (Fig. 2). The physician may either revise the dose, or continue with the current dose after entering a reason for overriding the alert. The same verification process is used after the physician enters the frequency and duration of the order. At this point the system will also compare the order against all other orders written to see if the weekly and lifetime dose maximum have been exceeded.

If the orderer is not an attending physician, and has overridden any alerts, the computer prompts the orderer to identify the attending physician who will approve the high dose orders. Pharmacy and nursing do not receive these orders until they have been approved. When the attending next signs on to the system, the computer will indicate that there are high dose chemotherapy orders to approve. Once authorization has been validated, the orders are

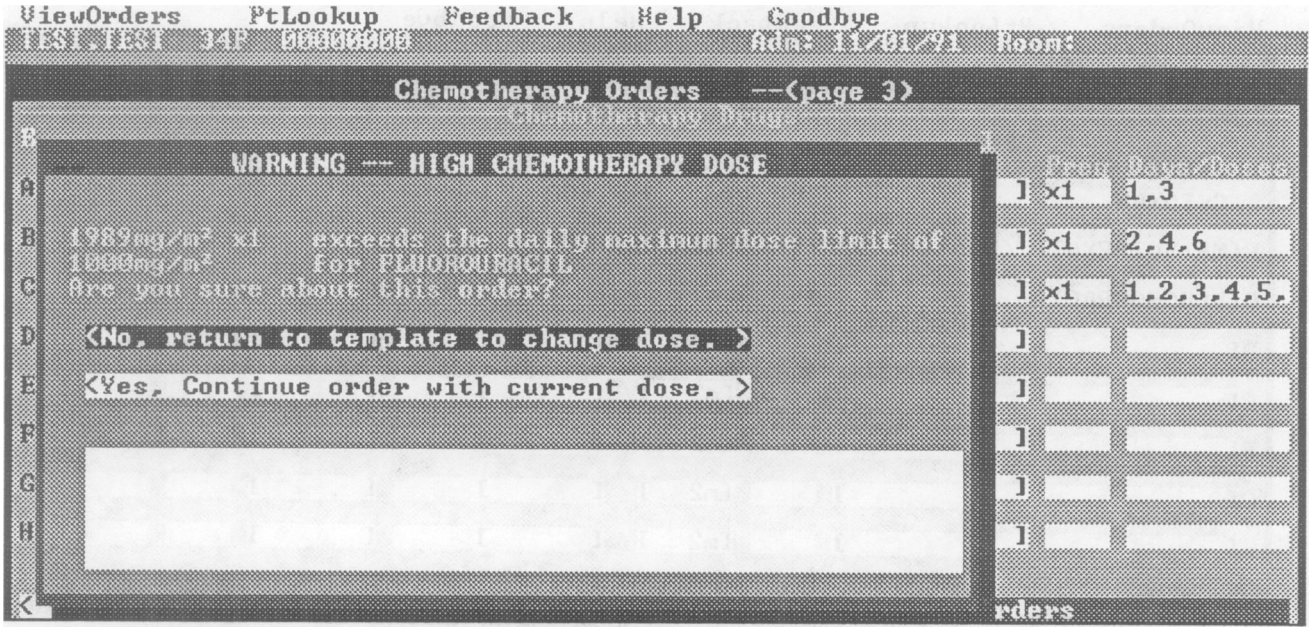

Figure 2. A warning screen, showing that an entered dose exceeds the pre-set limits. The orderer can override the warning, but must document the reason, and an attending physician must co-sign the order.

queued for nursing and pharmacy.

Operational rules

Certain rules and restrictions were implemented to ensure that orderers follow the paths which have been enhanced for safety. Chemotherapy orders can only be written via the template; this means that physicians can not have chemotherapy contained in other order sets, and can not use direct medication ordering screens or free-text modes to enter chemotherapy.

The physician is required to enter the patient's diagnosis, height and weight when entering the order. The nurse re-weighs the patient at the time of order acknowledgment, and enters that weight if it is different. If the weight has changed by more than five kilograms between the physician's and the nurse's observation, the orders must be re-signed by the physician with the newly recalculated doses.

Chemotherapy orders are not renewed, and are not automatically rewritten for post-operative patients and transferring patients. Any modification in chemotherapy must be entered through the template, where the ancillary orders and dose checking can take place.

Order communication

Orders are routed according to the location of the patient. For patients who are already admitted to the hospital, the computer finds the patient's location from the ADT system; then the orders are routed to a monitor screen on the appropriate nursing unit. For outpatients and patients scheduled to be admitted the orders are queued up for nurses in the oncology clinic. Once the patient arrives there, the system prompts the nurse to reconfirm the patient's diagnosis and body surface area. If the BSA changes, the chemotherapy doses are recalculated. The nurse countersigns the order, and the orders are then routed to the pharmacy.

Pre-admission ordering

A physician can write orders for a future outpatient visit, or for a future inpatient admission. For patients scheduled for future admission, the orders are also queued for the admitting department, thus eliminating the need for the physician to call for a booking. A reservation sheet is printed in admitting, including the patient's relevant demographic, financial, and clinical information.

As the session is filed, the physician's orders are separated into two sessions, so that the chemotherapy agents are separated from other orders such as IV fluids and anti-emetics. The sessions remain in a pre-admission status[7]. When the patient arrives in the pre-admitting area, the outpatient nurse is able to activate and execute the related orders (such as pre-hydration) first. Confirmation of a patient's height and weight is done, and the chemotherapeutic agents are mixed, in the pre-admission period. When the patient arrives on the inpatient unit, the inpatient nurse is able to officially countersign all pending orders; since the chemotherapy agents have already been mixed, they can be given to the patient as soon as possible thereafter.

Ambulatory orders

The process for an ambulatory visit is similar. The physician can write orders in advance of the patient's planned visit. Orders are activated when the patient arrives for the visit. Reconfirmation of BSA is made, and the pharmacy can mix and distribute the medication.

Outpatient orders may be activated by nursing only on the date which the provider has identified as the pending visit date, or on a date which precedes the visit date. If the visit date has passed, the orders require that the provider re-sign and change the visit date prior to activation.

RESULTS

Over a six month period, there were 1425 inpatient chemotherapy orders filed and 3042 outpatient chemotherapy orders. Each order usually represents multiple days of a single drug; two to five such orders would make up a standard round of combination chemotherapy. Of these, 201/1425 (14.1%) inpatient orders and 64/3042 (2.1%) outpatient orders had daily doses exceeding the limits.

This number is similar to the percentages of the previous year, before the warnings were implemented. However, in the new system, all of the high-dose orders had to be validated by a senior physician; presumably, these represented protocols which deliberately used the agent in a higher dose than the "standard" maximum. At present, the dose ceilings are not set for each protocol; thus, the limits are set for the lowest-dose protocol. Users of higher-dose protocols will see the warnings, and must verify that their protocol uses the higher dose.

Looking at the warnings generated by the system, a total of 512 daily-dose warnings were generated; 83 of these (16.2%) resulted in a change or cancellation

of the dose. There were 386 weekly-dose warnings; 84 (21%) resulted in a change or cancellation. The number of overrides is significantly higher than the number of high-dose orders ultimately filed; it appears that in many cases physicians entered an override, but then decided not to file (sign) the order.

DISCUSSION

The high number of overrides, and the large number of alerts altogether, reflects the conservative position adopted by the chemotherapy safety committee, ensuring that aggressive doses are carefully reviewed. As mentioned above, agents have different ceilings for different protocols, and users of one protocol need to override the default ceiling, which is written for the lowest-dose protocol. The large number of alerts complied with probably does not indicate that all 167 cancellations were impending ordering errors; possibly, the orderer decided to back off the order until it could be confirmed off-line. We plan to offer protocol-specific dose ceilings which can more precisely find possible errors and adverse events. We also plan to bind lab results more closely to the dosing rules, to further improve their specificity.

The system has been well received. The communication between pharmacy, physicians and nurses has been positively affected. Physicians welcome the ability to enter an entire protocol at one screen, and to be able to enter the protocol in advance of a scheduled admission. The use of the system in the outpatient clinic has improved documentation and helped to combine total chemotherapy records for a patient. Potentially inaccurate order interpretation by nursing or pharmacy is avoided due to clear and consistent physician ordering format.

The feedback from patients has also been positive. They find it comforting that two nurses and a pharmacist double check each order, and that sufficient information is provided to help guard against errors.

FUTURE ENHANCEMENTS

Protocol-based ordering is one of the most important upcoming developments in this system. This not only will allow for different dose ceilings for different protocols, but will also improve convenience by providing the drug names themselves on the form, ready for dose entry. Protocol-based ordering also adds a measure of safety by ensuring that only the agents specific to the protocol are ordered, although this has not been a source of error.

A new entity, Dana-Farber Partners Cancer Care, has developed as a joint venture between the Dana-Farber Cancer Institute (DFCI), BWH, and Massachusetts General Hospital. This venture is dedicated to providing more comprehensive patient-focused service, through standardization across the entire system. The chemotherapy ordering system described above is likely to become part of this venture, along with protocol-based ordering and a number of pharmacy-based safety measures that have been implemented at DFCI.

References

1. Teich JM, Hurley JF, Beckley RF, Aranow M. Design of an easy-to-use physician order entry system with support for nursing and anci.llary departments. Proc SCAMC 1992; 16:109-113.
2. Sittig DF, Stead WW. Computer-based physician order entry: the state of the art. J Am Med Informatics Assoc 1994; 1(2):108-23.
3. Wirtschafter D, Carpenter JT, Mesel E. A consultant-extender system for breast cancer adjuvant chemotherapy. Ann. Int. Med. 1979; 90:396-401.
4. Hickam DH, Shortliffe EH, Bischoff MB, Scott AC, Jacobs CD. The treatment advice of a computer-based cancer chemotherapy protocol advisor. Ann. Int. Med. 1985; 103:928-936.
5. Enterline, JP, Lenhard, RE. & Blum BI.(Eds.). A Clinical information system for oncology. New York: Springer-Verlag, 1989.
6. Teich JM, Glaser JP, Beckley RF, Aranow M, Bates DW, Kuperman GJ, Ward MA, Spurr CD. Brigham and Women's Hospital information systems. Proc 2nd annual Nicholas E. Davies symposium, in press.
7. Teich JM, Spurr CD, Schmiz JL, O'Connell EM, Thomas D, Enhancement of Clinician Workflow Using Computer Order Entry. J Am Med Informatics Assoc 2(5, supp), 1995, pp.459-463.